Rapid City Arterial Street Safety Study

Final Report

March 2012

prepared by:

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connecting and enhancing communities

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RAPID CITY INCORPORATED 1882 SOUTH DAKOTA

in conjunction with:

Rapid City Area MPO

RAPID CITY ARTERIAL SAFETY STUDY

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I. INTRODUCTION

A. *Study Background and Purpose*

The responsible investment of Rapid City resources in mitigating roadway safety problems is a difficult task. When making decisions affecting road safety, it is critical to understand that the expenditure of limited available funds on improvements in places where it prevents few injuries and saves few lives can mean that injuries will occur and lives will be lost by not spending them in places where more crashes could have been prevented[1]. It is the City of Rapid City's objective to maximize crash reduction within the limitations of available budgets by making arterial road safety improvements at locations where it does the most good or prevents the most crashes.

In an effort to better understand the existing crash problems on the arterial roadway network within Rapid City, the City, in conjunction with the Rapid City Area Metropolitan Planning Organization (MPO), identified the need to complete an arterial roadway safety study within Rapid City. The City enlisted Felsburg Holt and Ullevig (FHU) and Dream Design International (DDI) to complete this assessment with the goal of identifying high-priority traffic safety problems along arterial street segments in Rapid City and to conceptualize projects that will help to address those problems.

There are many considerations when it comes to improving roadway safety. These considerations are typically summarized as the 5 Es of roadway safety which include Evaluation, Engineering, Education, Enforcement and Emergency Services. The following provides a brief summary of each of these Es.

- Evaluation – Crash data needs to be reviewed and analyzed in order to identify problem locations and determine where money should be spent.
- Engineering – Based on identified crash patterns or problems spots, a list of capital improvement projects can be developed with the goal of identifying improvements that will reduce crashes and improve safety.
- Education – Educational programs are typically used to alter cultural norms that contribute to the occurrence of crashes and less safe roadways.
- Enforcement – Enforcement programs are developed to target unsafe driving behaviors in need of correction. These programs can be a partnership between law enforcement and the community.
- Emergency Services – Efficient response times and knowledgeable emergency service personnel are crucial in effectively responding when a crash does occur. Careful planning in the location of hospitals and response teams as well as thorough training is key.

This Arterial Street Safety Study focuses primarily on the Evaluation, Engineering and Enforcement Es. As mentioned, crash data have been evaluated and capital improvement and enforcement recommendations have been made that aim to address identified crash problems.

[1] Hauer, E., (1999) Safety Review of Highway 407: Confronting Two Myths. TRB

The analyses completed and documented in this report focus on the crashes on arterial roadway segments between major arterial to arterial intersections. City staff closely monitors the occurrence of crashes at the major intersections within the City so this study does not include crash analysis for major arterial intersections. The objectives of this study are as follows:

- Develop a citywide safety perspective to set localized crash frequency and severity in the context of other similar facilities in Rapid City
- Identify the top ten arterial crash segments within Rapid City using the Critical Crash Rate Method as outlined in the Highway Safety Manual (AASHTO, 2010). This method utilizes past crash totals, daily traffic volumes and arterial segment lengths to calculate crash rates
- Review each of the fatal crashes that occurred during the study period on arterial segments, to understand the circumstances surrounding each crash and determine if any measures can be taken to improve the safety of the arterial segments that each fatal crash occurred along
- Develop solutions with the greatest potential to improve arterial traffic safety for the top crash locations
- Prioritize future safety improvements to make sure that limited improvement funding is spent in the right places
- Provide the City of Rapid City with a repeatable methodology for analyzing arterial safety in the future using Geographic Information Systems (GIS) based methods

This report is based on the analysis of three years of crash history (January 2007 through December 2009) and a review of field geometry. The City is advised to verify, through field survey, the information included in this report regarding physical features and roadside characteristics for the design concepts included in this study.

B. Study Process

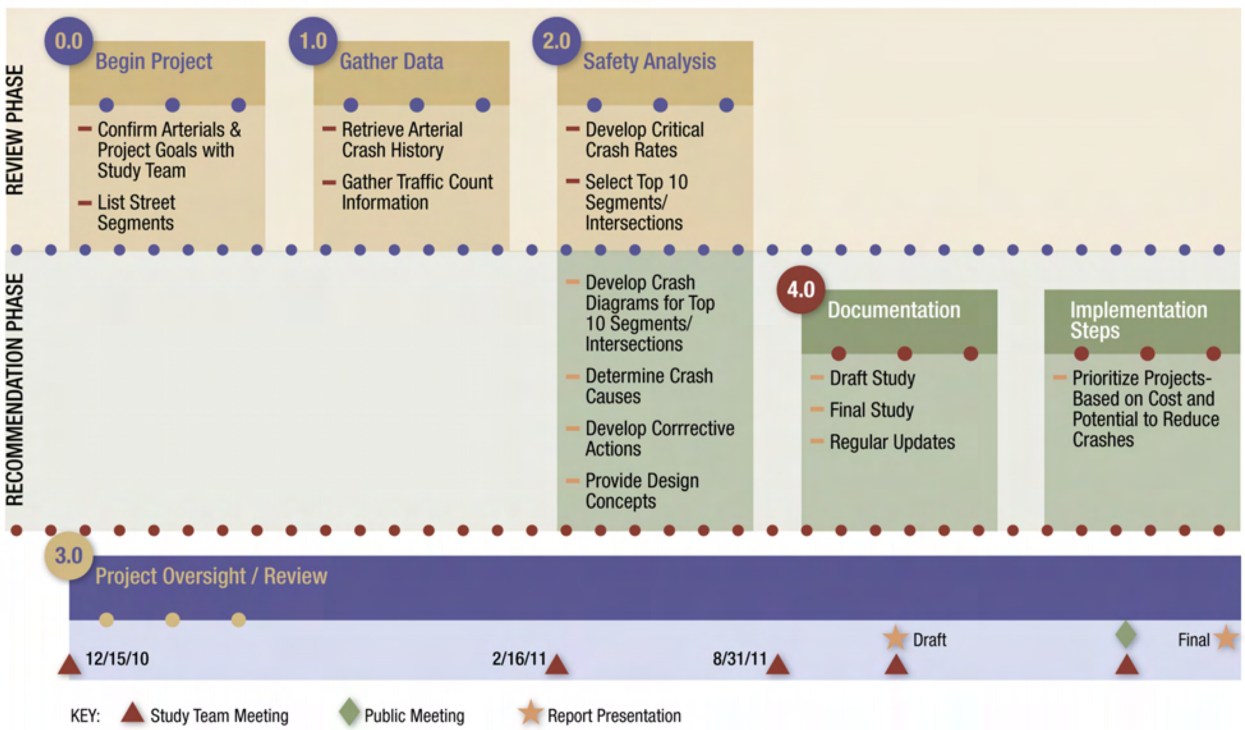
This arterial safety study began in December 2010 with the project kickoff meeting. The goal was to complete the data collection, the safety analyses and the documentation of this study within one year. Over the course of the project, Steering Committee meetings were held to discuss progress of the project and to make decisions for how to proceed with the analysis going forward. The Steering Committee was comprised of Rapid City, South Dakota Department of Transportation (SDDOT) and Federal Highway staff. The following is a list of the Steering Committee members:

- Patsy Horton – Rapid City Community Planning and Development Services
- John Less – Rapid City Engineering Services
- Kip Harrington – Rapid City Community Planning and Development Services
- Lt. James Johns – Rapid City Police
- Dan Staton – SDDOT
- Brad Remmich – SDDOT

- Josh Hinds – SDDOT
- Mark Hoines – Federal Highway Administration South Dakota

In addition to the Steering Committee meetings, a public meeting was held in conjunction with the completion of the draft report of the study. The goal of the public meeting was to provide the objectives of the study as well as an explanation of the methods and results that determined the top ten crash segments within the City. The final report will be presented to the City Council, City Planning Commission and Metropolitan Planning Organization in December 2011. **Figure 1** shows the work flow diagram developed for this project which outlines the tasks and major milestones of this project.

Figure 1. Arterial Safety Study Work Flow Diagram



II. ANALYSIS METHODOLOGY

A. Data Utilized for Analysis

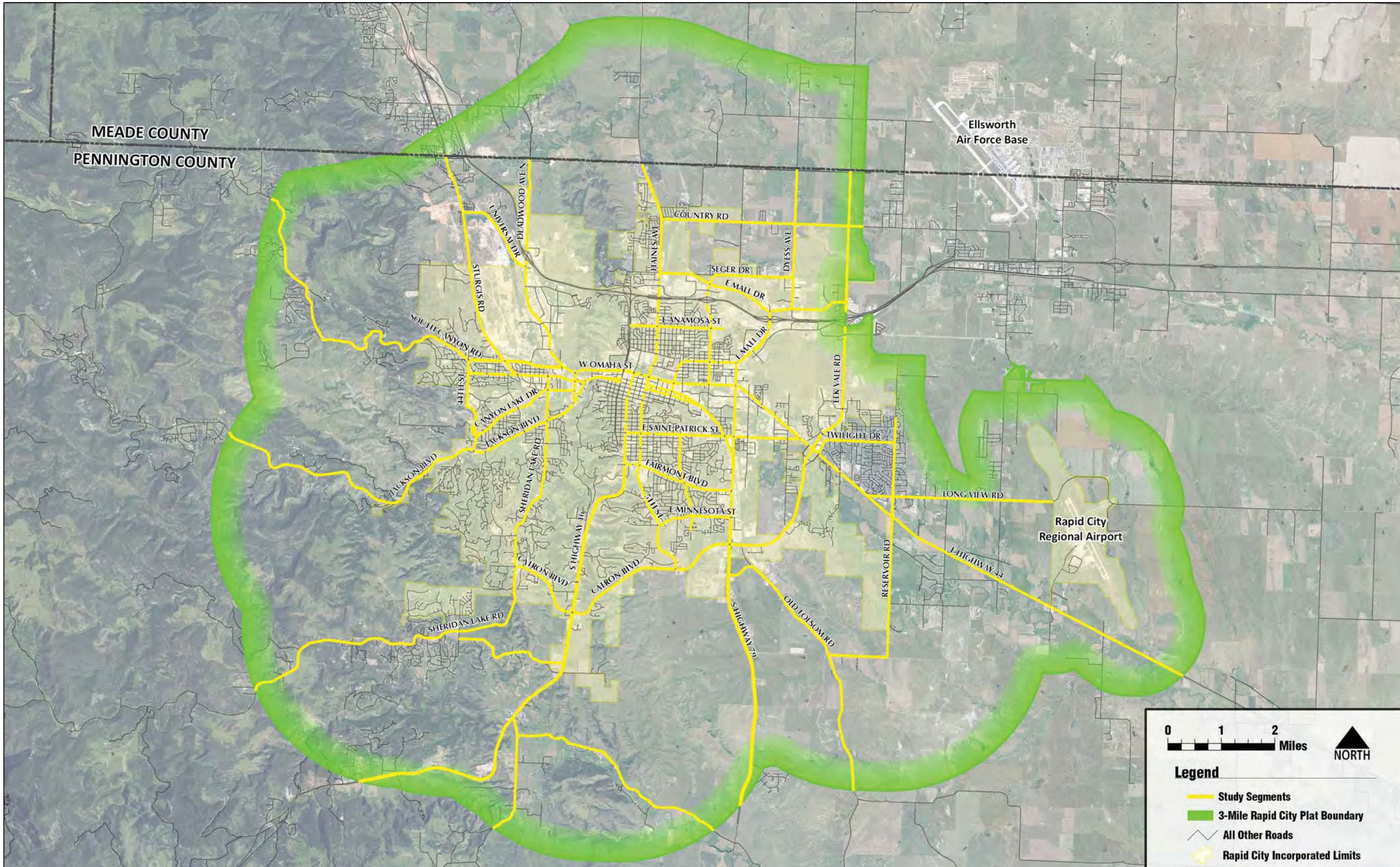
The crash, traffic volume, arterial roadway laneage and GIS data were provided by City and South Dakota Department of Transportation staff. The following provides a summary of the data utilized in this study:

- **Crash Data** – Arterial crash data represents a period of January 2007 through December 2009. The crash data used in this study was provided by the SDDOT in a Geographic Information Systems (GIS) file. The reason a three year study period was selected is that the arterial roadway network within Rapid City has changed in recent years due to various construction projects. In order to limit the effects a changing roadway network has on the crash experience, the most recent available three years of data were used. This was the direction agreed upon by the Steering Committee. In addition, the use of a three year study period helps to normalize the annual fluctuation in crash totals and prevents the selection of segments where a problem does not exist.
- **Daily Traffic Volumes** – Traffic count data were provided for each of the arterial roadway segments within Rapid City by City and Pennington County staff for the 2007 through 2009 study period. The City has a comprehensive traffic count program in which traffic volumes are collected on nearly every arterial roadway within the city on an annual basis. County data were utilized for the segments where count data was unavailable from the City. Arterial segments with more than one traffic count available for the three year study period were averaged to obtain a single representative daily traffic volume.
- **Arterial Roadway Laneage** – The number of travel lanes for each arterial were available in the City's arterial roadway network in GIS.
- **GIS Files** – As mentioned, the crash data was provided in a GIS file from the SDDOT. Each crash that occurred during the study period is represented by a point in this GIS file. The other GIS files utilized in this study were provided by City staff. The files utilized include:
  - The City 3-mile platting jurisdiction and the 1.5-mile airport boundary which were both used to define the limits of the study
  - The City arterial roadway network
  - The City intersection locations point file
  - The City traffic signals locations point file

Each of these data sources were utilized in this analysis and their application to this study will be discussed in more detail in the following sections.

B. Identification of Arterials for Study

As mentioned, the boundaries of the arterial safety study were set based on the City's 3-mile platting jurisdiction and the 1.5-mile boundary for the Rapid City Regional Airport. Any arterial roadway located outside of the plat and airport boundaries was removed from the study. Arterial roadways were identified based on the Rapid City Major Street Plan as furnished in GIS format. **Figure 2** shows the study boundaries and the arterials included in this analysis.



NORTH

Figure 2
Study Area

Several low volume, low speed, non-continuous arterials within the study area were removed from the study. The arterial segments in this category generally have daily volumes of less than 1,000 vehicles per day (vpd) and do not provide for longer trip lengths. The study Steering Committee discussed the removal of these arterials and agreed that if included, the statistics from these arterial segments would skew the crash rate averages due to their low volume and low crash occurrences. There were a total of 14 arterial segments removed based on these criteria. **Table 1** lists the excluded arterial segments.

Table 1. Arterials Removed from Analysis

Roadway	Location	Reason(s)
Creek Drive	Entire arterial segment	Non continuous arterial without traffic count
Elk Vale / Hwy 44 Ramps	At interchange	Should not be considered arterial segments
Airport Road	Entire arterial segment	Non continuous arterial without traffic count
Mickelson Drive	Entire arterial segment	Non continuous arterial without traffic count
Concourse Drive	Entire arterial segment	Non continuous arterial without traffic count
Anamosa Street	Just west of Elk Vale Rd.	Non continuous arterial without traffic count
Cheyenne Boulevard	Entire arterial segment	Non continuous arterial without traffic count
Edwards Street	Entire arterial segment	Non continuous arterial without traffic count
Eglin Street	Entire arterial segment	Non continuous arterial without traffic count
N. Plaza Drive	Entire arterial segment	Non continuous arterial without traffic count
Commerce Road	Entire arterial segment	Non continuous arterial without traffic count
Park Drive	Entire arterial segment	Short arterial without traffic count
Corral Drive	Entire arterial segment	Non continuous arterial without traffic count
Dunsmore Road	Entire arterial segment	Non continuous arterial without traffic count

C. Arterial Segmentation using Geographic Information Systems (GIS)

The arterial roadways within the study area were divided into shorter sub segments. The following methodology was used to complete the segmentation of the 160 miles of arterial roadways within the study area:

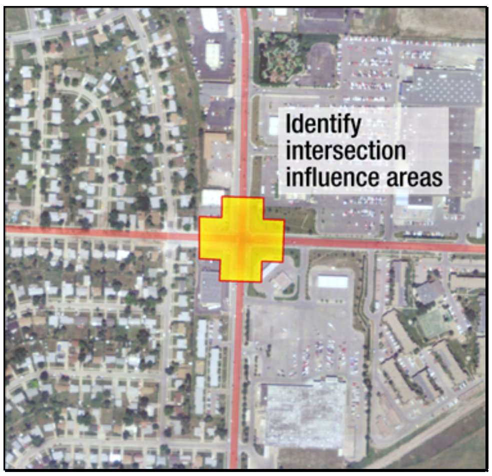
- All arterial to arterial intersections within the study area were isolated and buffered within GIS to remove the major intersections from the analysis. Each intersection buffer was based on an influence area along each intersection approach. As shown in **Table 2**, the size of each buffer was determined by the type of traffic control in place at the intersection. These intersection buffer sizes are currently in use by Rapid City staff when completing safety analyses for intersections and were used in this study to be consistent with current City practice.

Table 2. Intersection and Arterial Buffer Sizes

Location Type	GIS Buffer Size
Signalized Arterial Intersections	200 feet
All Way Stop Controlled Arterial Intersections	150 feet
All Other Stop Controlled Arterial Intersections	100 feet
Arterial Roadway Buffer Widths	20 feet

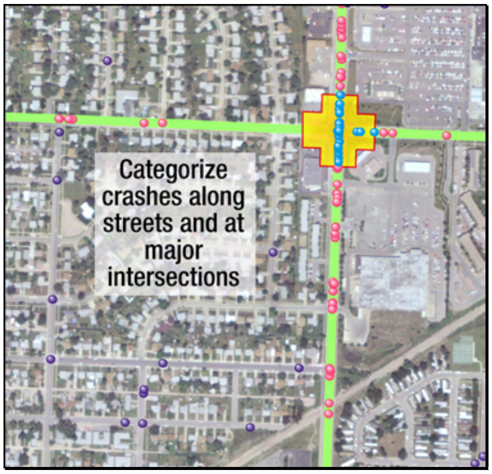
The distances shown in **Table 1** are measured in each direction from either the center point of the intersection or the center line of the arterial segment. **Figure 3** shows an example of an intersection influence area.

Figure 3. Typical Intersection Influence Area



- Crashes were identified as occurring within a major intersection influence area or along an arterial segment, and those occurring at a major intersection were removed from further consideration. Crashes that occurred along each of the 249 arterial segments were retained for further study. **Figure 4** shows an example of arterial segment crashes as well as the intersection related crashes removed from the analysis.

Figure 4. Classification of Crash Data Points



- The number of crashes was associated with the segment daily traffic volume, number of lanes and segment length. Each of the 249 arterial segments and associated information were then carried forward for analysis using the Critical Crash Rate method. This approach is generally consistent with the methods approved by the SDDOT. Use of this methodology was supported by the project Steering Committee.
- Of note, the central business district crashes were analyzed separately from the other arterial roadway crashes due to the unique geometric and travel conditions of the downtown area. The crashes in the downtown area will be discussed in more detail later in this report.

D. Critical Crash Rate Methodology

The Critical Crash Rate methodology is outlined in the Highway Safety Manual (AASHTO, 2010). This method compares the observed crash rate for an arterial segment to a critical crash rate that is unique for each arterial segment. The observed crash rate for a segment is calculated by dividing the number of crashes on the segment by the million vehicle miles of travel (MVMT) for the segment. The MVMT takes the daily traffic of the segment, the length of the segment and the number of years in the analysis (3 years) into account.

The critical crash rate is a threshold value that when compared to the crash rate for a segment can help to determine if the crash experience on a given segment is unusual or not. This threshold is developed by developing city wide crash rates for arterial segments with similar characteristics. For the purposes of this analysis, the number of travel lanes on each arterial segment was used to define the segment grouping classifications. For this analysis there are seven groups which include:

- 2-lane arterials
- 3-lane arterials
- 4-lane arterials

- 5-lane arterials
- 6-lane arterials
- 4-lane divided arterials
- 6-lane divided arterials

Citywide average crash rates were calculated for each of these arterial classifications. In addition, the P-value used in this analysis was 1.645 which corresponds to a 95 percent confidence level in a one-tailed Poisson distribution. These values, as well as the MVMT, for each segment were used to calculate the critical crash rate for each segment. Each arterial segment was then ranked according to its critical crash ratio which is the segment's observed crash rate divided by the critical crash rate.

In general, a segment with a crash ratio greater than 1.0 would be flagged for further analysis. However, for the purposes of this report, the critical crash ratio was used to rank the segments in order to identify the 10 worst crash segments for further analysis. A table showing the results of the critical crash rate analysis for all 249 arterial segments can be found in **Appendix A**.

III. CRASH ANALYSIS AND SUMMARY OF RESULTS

A. Top Crash Segments

Critical crash rate calculations were completed for all 249 arterial segments both considering the total crashes as well as only the severe crashes. For the purposes of this analysis, a severe crash is a crash that has been reported as a fatal, incapacitating injury or non-incapacitating injury crash. Both “possible injury” and “no injury” crashes have been classified as a property damage only (PDO) crash. The purpose of completing both total and severe crash rate calculations was to ensure that locations with a demonstrated history of severe crashes were given due consideration in the study. An arterial segment that did not make the top ten arterial list based on the total critical crash ratio but did make the top ten list based on the severe critical crash ratio list could be considered for further analyses.

A total of 14 top crash segments were identified for preliminary analysis. This top segment crash list and the preliminary analyses were presented to the Steering Committee on August 31, 2011. Through discussions with the Steering Committee, the list was reduced to ten arterial segments identified for more in depth analysis to be included in this report. **Table 3** shows the ten crash segments indentified for analysis as well their critical crash ratios. Each segment is discussed in more detail in the following sections. As mentioned, the complete segment rankings for all 249 segments can be found in **Appendix A.**

Table 3. Top Ten Crash Segments

Segment Number	Total Crash Rank (Severe Crash Rank)	Road Segment Name	From	To	Total Crashes (Severe Crashes)	Critical Crash Ratio Total (Critical Crash Ratio Severe)
Segment 1	1 (2)	Haines Ave	Lindbergh	I-90	33 (8)	2.43 (1.89)
Segment 2	2 (1)	Haines Ave	I-90	Disk	31 (8)	2.30 (1.88)
Segment 3	4 (3)	Saint Joseph St	5th	East Blvd	27 (5)	2.02 (1.39)
Segment 4	7 (145)	Jackson Blvd	City Limit	Chapel	15 (0)	1.87 (0.00)
Segment 5	10 (5)	W Main St	Sheridan Lake	Mountain View	49 (11)	1.66 (1.36)
Segment 6	14 (43)	N LaCrosse St	Anamosa	Meridian	18 (2)	1.42 (0.74)
Segment 7	49 (7)	S Highway 16 NB	Neck Yoke	Busted 5 Ct	41 (8)	0.90 (1.26)
Segment 8	15 (20)	N LaCrosse St	E North	Anamosa	53 (10)	1.39 (0.99)
Segment 9	26 (14)	W Omaha St	Mountain View	West Blvd	40 (12)	1.11 (1.08)
Segment 10	35 (17)	E Saint Patrick St	Elm	St Joseph	28 (8)	0.77 (1.04)

IV. INDIVIDUAL ARTERIAL SEGMENTS

This section of the report includes detailed information about each of the top ten segments analyzed in this study. Contents include a description of the road design, overview of crash history, identified correctable crash pattern(s) and mitigation concepts. The mitigation concepts developed for each of the top crash segments in this report are a rendering of what could be completed. If implemented, each concept will require further engineering analysis and / or design prior to construction.

A. Segment 1 – Haines Avenue (Lindbergh Avenue to Interstate 90)

Segment Description

This segment of Haines Avenue is located just south of Interstate 90 (I-90) adjacent to the Shopko Shopping Center. The segment is approximately 0.20 miles in length and runs from Lindbergh Avenue on the south to I-90 on the north. Haines Avenue has two northbound lanes, two southbound lanes and a center left turn lane. The center median on Haines Avenue is painted. There is curb and gutter throughout this segment. The posted speed limit on Haines Avenue is 35 miles per hour (mph). The average daily traffic for this segment during the study period was about 19,900 vpd.

Crash History and Correctable Crash Patterns

During the three-year study period, there were a total of 33 crashes on this segment. Of these, 25 were Property Damage Only (PDO) crashes and 8 were injury crashes. There were no fatal crashes on this segment during the study period. The majority of the crashes were angle crashes (mostly broadsides) with rear-end crashes the second most common crash type. A diagram showing the type and location of each crash for this segment can be found in **Appendix B**.

As can be seen on the crash diagram, the majority of crashes on this segment occurred at the unsignalized intersection with Knollwood Drive. The majority of the crashes at this intersection were broadside type crashes that occurred when a vehicle from Knollwood Drive failed to yield the right-of-way and pulled out in front of either a northbound or southbound vehicle on Haines Avenue. In addition to the angle crashes at this intersection, there are also angle (access related) crashes at the intersections with Wright Street and Curtis Street.

Mitigation Measures and Concepts

Based on the angle crash pattern along this segment, consideration should be given to developing an access management plan for the corridor. A concept of a possible access management plan developed for this segment can be found in **Appendix B**. This concept would construct a raised median and provide one full movement intersection along the segment at the Wright Street intersection. If this concept is implemented, the City should consider completing a traffic signal warrant study per the Manual on Uniform Traffic Control Devices (MUTCD) (Federal Highway Administration, 2009) for the Wright Street intersection to determine if the intersection should be signalized or remain unsignalized. In addition, travel speeds should also be monitored if this concept is implemented and additional speed enforcement conducted if travel speeds are found to be a problem on Haines Avenue. All other driveways and intersections (including Knollwood Drive) would be restricted to right-in/right-out or ¾ movement intersections. Of note, this concept would not preclude the City from continuing with plans to reroute Knollwood Drive to Lindbergh Avenue as has been discussed in the past.

It is also worth noting that the intersection of Knollwood Drive and Haines Avenue was evaluated as part of the SDDOT 2010 Roadway Safety Improvement Program (RSI). The recommendation in the DOT study is to sign the Knollwood Drive approaches for no left turns during afternoon hours and provide enforcement during that time.

B. Segment 2 – Haines Avenue (I-90 to Disk Drive)

Segment Description

This segment of Haines Avenue is located just north of I-90. The segment is approximately 0.16 miles in length and runs from I-90 on the south to Disk Drive on the north. Haines Avenue has two northbound lanes, two southbound lanes and a center left turn lane. The center median on Haines Avenue is painted. There is curb and gutter throughout this segment. The posted speed limit on Haines Avenue is 35 miles per hour (mph). The average daily traffic for this segment during the study period was about 25,000 vpd.

Crash History and Correctable Crash Patterns

During the three-year study period, there were a total of 31 crashes on this segment. Of these, 23 were PDO crashes and 8 were injury crashes. There were no fatal crashes on this segment during the study period. There were an even split between angle type and rear end type crashes on this segment. A diagram showing the type and location of each crash for this segment can be found in **Appendix C**.

As can be seen on the crash diagram, the majority of the angle crashes are related to intersections and driveways along the segment. Most of the approach turn type angle crashes occurred at Howard Street while the majority of the broadside type angle crashes occurred at the Conoco driveway. Nearly all of the rear end crashes occurred on the southbound approach to the I-90 interchange intersection.

Mitigation Measures and Concepts

Based on the angle crash pattern along this segment, consideration should be given to reconfiguring local access intersections along the segment. A concept of a possible access reconfiguration for this segment can be found in **Appendix C**. If implemented, this concept would construct a raised median and would restrict all driveways between Howard Street and Disk Drive to right-in / right-out or ¾ movement intersections. As can be seen on the concept diagram in **Appendix C**, recommendations have also been made regarding u-turn locations on Haines Avenue as well as improving access to Disk Drive for the retail developments along the east side of Haines Avenue. Travel speeds should also be monitored if this concept is implemented and additional speed enforcement conducted if travel speeds are found to be a problem on Haines Avenue.

In addition, consideration should be given to reviewing the visibility of the existing signal heads on the southbound approach at the intersection with I-90 and reviewing the length of the green interval for the southbound left turn. Improving the visibility of the signal heads could help to reduce the number of rear end type crashes. In addition, lengthening the southbound left turn phase could help to reduce the number of rear end type crashes.

C. Segment 3 – Saint Joseph Street (5th Street to East Boulevard)

Segment Description

This segment of Saint Joseph Street is located on the east side of downtown. The segment is approximately 0.44 miles in length and runs from 5th Street on the west to East Boulevard on the east. Saint Joseph Street is a one-way roadway eastbound and has three travel lanes with on-street parking, both angle and parallel. There is curb and gutter throughout this segment. The posted speed limit on Saint Joseph Street is 30 miles per hour (mph). The average daily traffic for this segment during the study period was about 10,500 vpd.

Crash History and Correctable Crash Patterns

During the three-year study period, there were a total of 27 crashes on this segment. Of these, 22 were PDO crashes and 5 were injury crashes. There were no fatal crashes on this segment during the study period. The most predominant crash type were sideswipe same direction crashes (13) followed closely by broadside type crashes (11). A diagram showing the type and location of each crash for this segment can be found in **Appendix D**.

As can be seen on the crash diagram, the sideswipe same direction crashes are spread throughout the corridor but are typically on the approach to an intersection. A large portion of these crashes occurred due to illegal lane changes when a vehicle in the center lane of traffic attempted to make a left turn onto an intersecting side street.

Nearly all of the broadside type crashes occurred at the intersection of Saint Joseph Street with 4th Street. These crashes typically occurred when a vehicle on 4th Street misjudged the gap in traffic and was struck by an eastbound vehicle on Saint Joseph Street. However, sight distance from the stop bar on 4th Street is also restricted due to the angled parking on Saint Joseph Street (as seen in **Figure 5**) and could be a contributing factor to these crashes.

Mitigation Measures and Concepts

Based on the angle crash pattern and restricted sight distance at 4th Street, consideration should first be given to removing the existing parking on Saint Joseph Street just west of 4th Street. This would help to improve the sight distance and could reduce the number of angle crashes. However, if the parking cannot be removed or if the angle crash problem does not improve, consideration should be given to installing a traffic signal at the St. Joseph Street/4th Street intersection. The number of broadside crashes during the study period meets Part B of the criteria for Warrant 7 in the MUTCD. However, further analysis should be considered to determine if Parts A and C of Warrant 7 are also met. If warranted, the installation of a traffic signal at this location would help to reduce the number of broadside crashes at this intersection.

Consideration should be given to signing and striping the approaches to the intersections along this segment with lane use arrows. This could help to reduce the number of sideswipe same direction crashes on the approaches to the intersections.

A concept showing both the proposed traffic signal and striping developed for this segment can be found in **Appendix D**.

Figure 5. Saint Joseph Street and 4th Street Sight Distance

D. Segment 4 – South Dakota 44 (Jackson Boulevard) (City Limit to Chapel Lane)

<u>Segment Description</u>

This segment of Jackson Boulevard is located on the western side of Rapid City. The segment is approximately 1.08 miles in length and runs from Chapel Lane on the east to the City Limit on the west. Jackson Boulevard is a four-lane roadway with two lanes in the eastbound direction and two lanes in the westbound direction. There is not a center turn lane. There is curb and gutter throughout this segment. The posted speed limit on Jackson Boulevard is 45 miles per hour (mph). The average daily traffic for this segment during the study period was about 4,600 vpd.

<u>Crash History and Correctable Crash Patterns</u>

During the three-year study period, there were a total of 15 crashes on this segment, all of which were PDO crashes. There were no fatal crashes on this segment during the study period. The most predominant crash types were wild animal type crashes (7) followed by angle type crashes (4). A diagram showing the type and location of each crash for this segment can be found in **Appendix E**.

As can be seen on the crash diagram, the wild animal type crashes are spread throughout the segment. Since no pattern exists due to the inconsistent location of the crashes, no recommendations have been made to address this crash type.

Nearly all of the angle type crashes occurred at the intersection of Jackson Boulevard with Cleghorn Canyon Road. These crashes typically occurred when a vehicle turning left from Cleghorn Canyon Road misjudged the gap in traffic and was struck by a westbound vehicle on Jackson Boulevard.

Mitigation Measures and Concepts

Based on the angle crash pattern at Cleghorn Canyon Road, consideration should be given to installing an intersection warning sign (W2-2) and a supplemental advisory speed plaque (W13-1P) on the westbound approach to the intersection. A similar sign group is currently in place on the eastbound approach to the intersection.

In addition, consideration should be given to improving the sight distance for vehicles looking to the south from Cleghorn Canyon Road. **Figure 6** shows the current obstructions in place for vehicles at this intersection.

Figure 6. Jackson Boulevard and Cleghorn Canyon Road Sight Distance

A concept showing the recommended signing and striping for this segment can be found in **Appendix E**.

E. Segment 5 – West Main Street (Sheridan Lake Road to Mountain View Road)

Segment Description

This segment of West Main Street is west of Mountain View Road and is adjacent to the Baken Park Shopping Center for a portion of the segment. The segment is approximately 0.45 miles in length and runs from Sheridan Lake Road to Mountain View Road and also crosses Rapid Creek. West Main Street has two eastbound lanes, two westbound lanes and a center left turn lane. The center median on West Main Street is painted. There is curb and gutter throughout this segment. The posted speed limit on West Main Street is 35 miles per hour (mph). The average daily traffic for this segment during the study period was about 22,800 vpd.

Crash History and Correctable Crash Patterns

During the three-year study period, there were a total of 49 crashes on this segment. Of these, 38 were PDO crashes and 11 were injury crashes. There were no fatal crashes on this segment during the study period. The most predominant crash types were angle type crashes (25) followed by rear end type crashes (16). It is also worth noting that there were three crashes involving a bicycle. A diagram showing the type and location of each crash for this segment can be found in **Appendix F**.

As can be seen on the crash diagram, the angle and rear end type crashes were spread throughout the corridor and were typically associated with driveways or intersections along the segment. The locations with the highest concentration of crashes include the driveways to / from the Baken Park Shopping Center. The driveways to / from McDonalds as well as the intersections of Dakota Drive, Sheffer Street and Piedmont Street also had a high concentration of crashes.

Mitigation Measures and Concepts

Based on the angle crash pattern along this segment, consideration should be given to developing an access management plan for the arterial segment. A concept of a possible access management plan developed for this segment can be found in **Appendix F**. If implemented, this concept would construct a raised median along the entire length of the segment and would restrict nearly all of driveways on the segment to right-in / right-out or ¾ movement intersections. The only exception would be the intersection with Dakota Drive which is recommended to remain a full movement access. There is also one driveway recommended for closure. If this concept is implemented, consideration should be given to completing a traffic signal warrant study per the MUTCD at Dakota Drive and, if warranted, installing a traffic signal at this location. In addition, travel speeds should also be monitored if this concept is implemented and additional speed enforcement conducted if travel speeds are found to be a problem on West Main Street.

In addition, the recently released Rapid City Area Bicycle and Pedestrian Master Plan (Alta / KL&J, July 2011) recommended that a bike lane be constructed along West Main Street. Due to the occurrence of bicycle crashes along this segment, consideration should be given to constructing the bike lane in association with the access management project.

The concept for this segment in **Appendix F** shows both the raised median and the bike lane.

F. Segment 6 – LaCrosse Street (Anamosa Street to Meridian Lane)

Segment Description

This segment of LaCrosse Street is located just north of Anamosa Street and is adjacent to the Wal-Mart Shopping Center. The segment is approximately 0.06 miles in length and runs from Anamosa Street on the south to Meridian Lane on the north. LaCrosse Street has two northbound lanes, two southbound lanes and a center left turn lane. The center median on LaCrosse Street is painted. There is curb and gutter throughout this segment. The posted speed limit on LaCrosse Street is 35 miles per hour (mph). The average daily traffic for this segment during the study period was about 21,200 vpd.

Crash History and Correctable Crash Patterns

During the three-year study period, there were a total of 18 crashes on this segment. Of these, 16 were PDO crashes and 2 were injury crashes. There were no fatal crashes on this segment during the study period. The most predominant crash types were rear end type crashes (10) followed by angle type crashes (5). It is also worth noting that all of the angle crashes were broadside crashes that occurred at the unsignalized Wal-Mart access. A diagram showing the type and location of each crash for this segment can be found in **Appendix G**.

As can be seen on the crash diagram, the rear end crashes were spread throughout the corridor. The largest concentration of crashes was focused on the Wal-Mart access with a mix of rear end and broadside crashes.

Mitigation Measures and Concepts

Based on the concentration of crashes at the unsignalized Wal-Mart access primarily related to the number of angle crashes at this location, consideration should be given to restricting the driveway to a right-in / right-out access only. A concept of the new configuration of this access can be found in **Appendix G**. If implemented, this concept would construct a raised channelization island. The implementation of this concept would assist compliance and reduce the number of broadside crashes at this intersection. It is also worth noting that this shopping center will still have a full movement signalized access at Meridian Lane at which exiting vehicles can head south on LaCrosse Street.

G. Segment 7 – Northbound US Highway 16 (Neck Yoke Road to Busted 5 Court)

Segment Description

This segment of northbound US Highway 16 is located south of Rapid City and is near Bear Country USA. The segment is approximately 3.68 miles in length and runs from Busted 5 Court on the south to Neck Yoke Road on the north. Highway 16 is a four lane divided highway with a depressed center median. The posted speed limit on Highway 16 is 65 miles per hour (mph). The average daily traffic in the northbound direction for this segment during the study period was about 6,200 vpd.

Crash History and Correctable Crash Patterns

During the three-year study period, there were a total of 41 crashes on this segment in the northbound direction. Of these, 33 were PDO crashes and 8 were injury crashes. There were no fatal crashes on this segment during the study period. The most predominant crash types were wild animal type crashes (21) followed by run-off-road type crashes (9) and angle type crashes (6). Run-off-road type crashes include guardrail / cable rail crashes as well as any crash where the vehicle left the travel lane. A diagram showing the type and location of each crash for this segment can be found in **Appendix H**.

As can be seen on the crash diagram, the majority of the wild animal type crashes were located in the curve to the east of Bear Country USA. Many of these crashes occurred around dawn or dusk. In addition, many of the angle crashes occurred when a vehicle that was either slowing to turn into one of the paved median cuts or accelerate from one of the pave median cuts was struck by another vehicle on Highway 16.

Mitigation Measures and Concepts

Based on the concentration of wild animal type crashes, consideration should be given installing wild animal fences through the curve to the east of Bear Country USA. Openings in the fence should be provided for existing driveways as well as at locations designated as crossings for the wild animals. If provided, consideration should be given to signing all designated crossings with deer crossing signs (W11-3) as well as flashing beacons.

In addition, consideration should be given to installing acceleration / deceleration lanes at several of the paved median cuts on the west end of the corridor. The acceleration / deceleration lanes will allow exiting / entering vehicles to safely exit or enter the paved median cuts.

Finally, consideration should be given to installing rumble strips and using safety edge paving techniques on the shoulder where there is not guardrail or cable rail against the shoulder. An informational brochure on safety edge has been place in **Appendix H**.

The proposed location of the wild life fencing as well as the acceleration / deceleration lanes can be found in **Appendix H**.

H. Segment 8 – LaCrosse Street (E. North Street to Anamosa Street)

Segment Description

This segment of LaCrosse Street is located just south of Anamosa Street. The segment is approximately 0.55 miles in length and runs from Anamosa Street on the north to E. North Street on the south. LaCrosse Street has two northbound lanes, two southbound lanes and a center left turn lane. The center median on LaCrosse Street is painted. There is curb and gutter throughout this segment. The posted speed limit on LaCrosse Street is 35 miles per hour (mph). The average daily traffic for this segment during the study period was about 24,800 vpd.

Crash History and Correctable Crash Patterns

During the three-year study period, there were a total of 53 crashes on this segment. Of these, 43 were PDO crashes and 10 were injury crashes. There were no fatal crashes on this segment during the study period. The most predominant crash types were angle type crashes (31) followed by rear end type crashes (15). A diagram showing the type and location of each crash for this segment can be found in **Appendix I**.

As can be seen on the crash diagram, the majority of the angle type crashes occurred at the intersections with public streets. The only private driveway with a significant number of angle crashes was the north driveway to / from the former Sam's Club parking lot.

The rear end type crashes were generally spread throughout the corridor and were typically due to a vehicle stopping to turn into a driveway or a vehicle stopping for the existing railroad crossing.

Mitigation Measures and Concepts

Based on the concentration of crashes at the unsignalized former Sam's Club access primarily related to the number of angle crashes at this location, consideration should be given to restricting the driveway to a right-in / right-out access only. A concept of the new configuration of this access can be found in **Appendix I**. This concept would construct a raised channelized island on LaCrosse Street. The implementation of this concept would assure compliance and reduce the number of broadside crashes at this intersection.

In addition, consideration should be given to completing a traffic signal warrant study at the intersection with Monroe Street. The number of broadside crashes during the study period meets Part B of the criteria for Warrant 7 in the MUTCD. Further analysis should be considered to determine if Parts A and C of Warrant 7 are also met. However, it is worth noting that the 24/7 program located on Monroe Street moved in 2009 which may lead to a reduction in the traffic and number of crashes at this intersection. If angle crashes are still a problem at this intersection, the installation of a traffic signal at this location, if warranted, would help to reduce the number of broadside crashes at this intersection.

In addition, consideration should be given to relocating the existing utility pole located on the southwest corner of the Monroe Street intersection. This pole was struck twice during the study period likely due to its close spacing to the edge of the roadway.

It is worth noting, that the intersection with Van Buren Street would also likely warrant a traffic signal based on the criteria of Warrant 7 but due to the intersection's close proximity to the railroad crossing, a traffic signal is not recommended for this intersection.

Finally, consideration should be given to installing automatic crossing gates at the existing railroad crossing. Currently, there are flashing lights, pavement markings and signs for this railroad crossing. However, based on the given ADT on LaCrosse Street and the number of trains that use this crossing daily (4), the crossing exposure factor is approximately 100,000. According to the Railroad – Highway Grade Crossing Handbook (FHWA, 2007), consideration should be given to installing automatic gates in addition to other active devices, such as flashing lights, at an at grade rail road crossing with an exposure factor this high. This measure would help to prevent any future vehicle / rail crashes on this corridor. However, it is important to note that several arterial at-grade railroad crossings in Rapid City are configured similar to the current LaCrosse Street crossing, reducing the urgency of changes to this crossing.

Each of the measures outlined above can be seen on the segment concept drawing in **Appendix I**.

I. Segment 9 – West Omaha Street (Mountain View Road to West Boulevard)

Segment Description

This segment of West Omaha Street is west of West Boulevard. The segment is approximately 0.83 miles in length and runs from Mountain View Road to West Boulevard. West Omaha Street has two eastbound lanes, two westbound lanes and a center left turn lane. The center median on West Omaha Street is painted. There is curb and gutter throughout this segment. The posted speed limit on West Main Street is 40 miles per hour (mph). The average daily traffic for this segment during the study period was about 15,400 vpd.

Crash History and Correctable Crash Patterns

During the three-year study period, there were a total of 40 crashes on this segment. Of these, 28 were PDO crashes and 12 were injury crashes. There were no fatal crashes on this segment during the study period. The most predominant crash types were angle type crashes (18) followed by rear end type crashes (16). A diagram showing the type and location of each crash for this segment can be found in **Appendix J**.

As can be seen on the crash diagram, the angle and rear end type crashes were spread throughout the corridor and were typically associated with driveways or intersections along the segment. However, the only substantial grouping of crashes with a correctable pattern was at the intersection with 12th Street. All of the angle crashes at this intersection occurred when one vehicle failed to yield the right-of-way to a vehicle traveling on West Omaha Street.

Mitigation Measures and Concepts

The City and SDDOT have both completed signal warrant studies at the 12th Street intersection in the past. To date, these studies have found that a traffic signal is not warranted at this intersection either from a traffic volume or crash standpoint. It is likely that this intersection may warrant signalization in the future but likely will not be needed until further development is completed north of Omaha Street. However, in an effort to be proactive, the City continually monitors traffic volumes at this intersection to determine if a traffic signal is needed. It is recommended the City continue with this count program into the future and consider installing a traffic signal when warranted.

The concept for this segment in **Appendix J** shows the location of the proposed traffic signal.

J. Segment 10 – Saint Patrick Street (Elm Avenue to Saint Joseph Street)

Segment Description

This segment of Saint Patrick Street is west of Saint Joseph Street. The segment is approximately 0.76 miles in length and runs from Elm Avenue to Saint Joseph Street. Saint Patrick Street has two eastbound lanes, two westbound lanes and a center left turn lane. The center median on Saint Patrick Street is painted. There is curb and gutter throughout this segment. The posted speed limit on West Main Street is 35 miles per hour (mph). The average daily traffic for this segment during the study period was about 12,400 vpd.

Crash History and Correctable Crash Patterns

During the three-year study period, there were a total of 28 crashes on this segment. Of these, 20 were PDO crashes and 8 were injury crashes. There were no fatal crashes on this segment during the study period. The most predominant crash types were angle type crashes (17) followed by rear end type crashes (4). A diagram showing the type and location of each crash for this segment can be found in **Appendix K**.

As can be seen on the crash diagram, the angle and rear end type crashes were spread throughout the corridor and were typically associated with driveways or intersections along the segment. Approximately 1/3 of the angle and rear end crashes occurred in poor roadway conditions and one driver was typically driving faster than appropriate for the conditions. Otherwise, no other correctable pattern has been identified for this segment.

Mitigation Measures and Concepts

Consideration should be given to reviewing snow removal procedures for this segment as well as providing additional speed enforcement.

K. Central Business District (Downtown) Crashes

For the purposes of this study, the downtown area of Rapid City was designated as the area bounded by Kansas City Street to Omaha Street and West Boulevard to 5th Street. The central business district crashes were analyzed separately from the other arterial roadway crashes due to the unique geometric and travel conditions of the downtown area. Based on a review of the crashes occurring within the central business district during the study period, the most common crash types were rear end crashes (50%), angle crashes (23%) and sideswipe same direction crashes (15%). A little over 92 percent of these crashes were property damage only crashes with the remaining 8 percent of crashes classified as injury crashes. It is worth noting, there was only one incapacitating injury crash in the downtown area during the study period and no fatal crashes.

The high occurrence of property damage crashes and low occurrence of injury crashes is not uncommon for a downtown area. This is primarily due to the low travel speeds and one way roadways common to the downtown area. Based on this, there does not appear to be a correctable crash pattern in the Rapid City downtown area. Therefore, no recommendations have been made in this study.

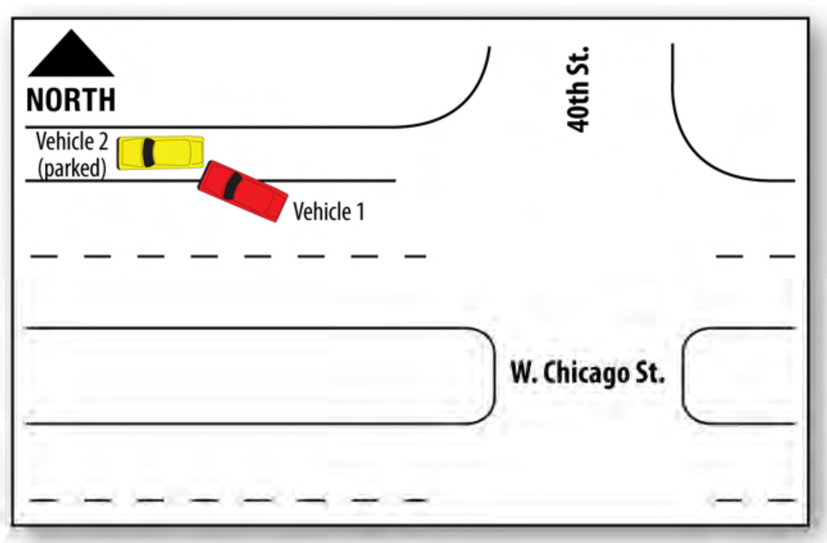
V. FATAL CRASH ANALYSIS

There were a total of 12 fatal crashes that occurred during the three-year study period along the 249 arterial roadway segments analyzed in this study. The crash report for each fatal crash was reviewed to understand the circumstances surrounding each crash and to determine if any measures can be taken to improve the safety of the arterial segments that each of these fatal crashes occurred along. The following provides a brief summary of each fatal crash that occurred during the study period and any recommendations to improve safety on the arterial segments where the crashes occurred.

A. February 28, 2007 – West Chicago Street just west of 40th Street

This crash occurred when vehicle 1 was westbound on Chicago Street and struck a legally parked vehicle (vehicle 2) on the north side of the street on the approach to 42nd Avenue (see **Figure 7**). This crash occurred in dry, daylight conditions around 2PM. The driver of vehicle 1 drifted to the right for an unknown reason and collided with the parked car (vehicle 2). The driver of vehicle 1 was not wearing a seat belt and made an impact with the steering wheel. The driver suffered fatal injuries due to the impact with the steering wheel.

Figure 7. West Chicago Street Fatal Crash Diagram



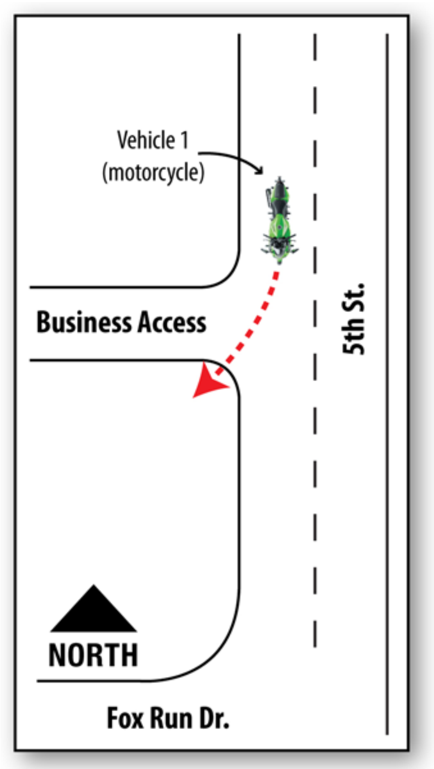
During the study period, there were 6 total crashes on this segment of West Chicago Street. There were 4 PDO crashes, 1 was an injury crash and 1 was the fatal crash. This segment is number 94 on the total crash critical crash ratio ranking list and number 22 on the severe crash critical crash ratio ranking list.

Based on the isolated circumstances of this fatal crash and due to the low crash total on this segment, there does not appear to be a pattern in need of correction.

B. April 30, 2007 – 5th Street just north of Fox Run Drive

This crash occurred when vehicle 1, a motorcycle, was in the southbound direction on 5th Street. The driver lost control, laid the bike on its side and skidded off the right side of the road (see **Figure 8**). This crash occurred in dry, daylight conditions around 1PM. The driver suffered fatal injuries due to the impact with the road surface.

Figure 8. 5th Street at Business Access Fatal Crash Diagram



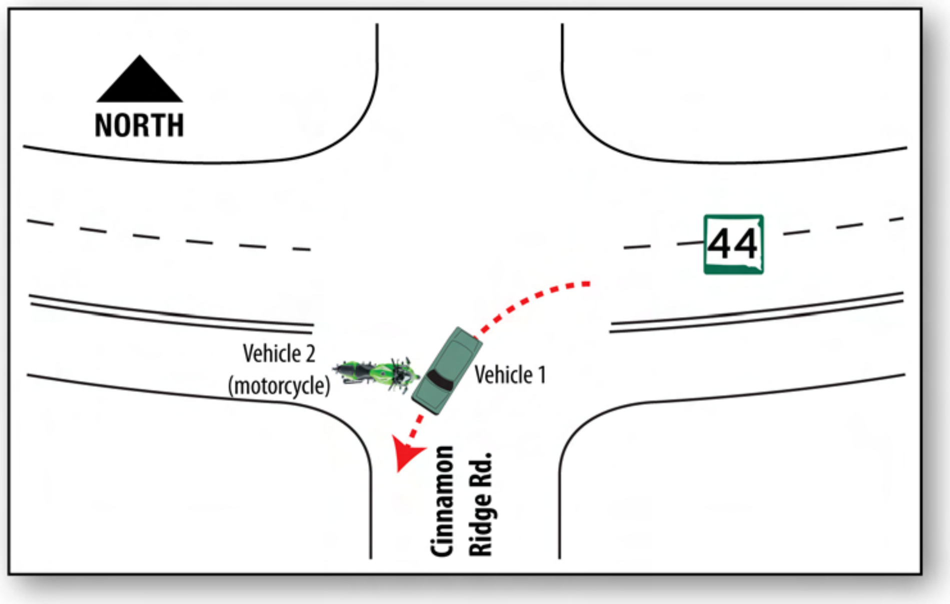
During the study period, there were 18 total crashes on this segment. There were 15 PDO crashes, 2 injury crashes and 1 was the fatal crash. This segment is number 31 on the total crash critical crash ratio ranking list and is number 57 on the severe crash critical crash ratio ranking list.

Based on the isolated circumstances of this fatal crash, there does not appear to be a pattern in need of correction on this segment.

C. May 18, 2007 – South Dakota Highway 44 at Cinnamon Ridge Road

This crash occurred when vehicle 1 in the westbound direction attempted to make a left turn onto Cinnamon Ridge Road and pulled out in front of vehicle 2, a motorcycle that was eastbound on SD 44. The driver of vehicle was attempting to put a water bottle down while making the left turn and did not see vehicle 2. The two vehicles collided and the driver of vehicle 2 was thrown onto the roadway and was fatally injured (see **Figure 9**). This crash occurred in dry, daylight conditions around 2PM.

Figure 9. Highway 44 at Cinnamon Ridge Fatal Crash Diagram



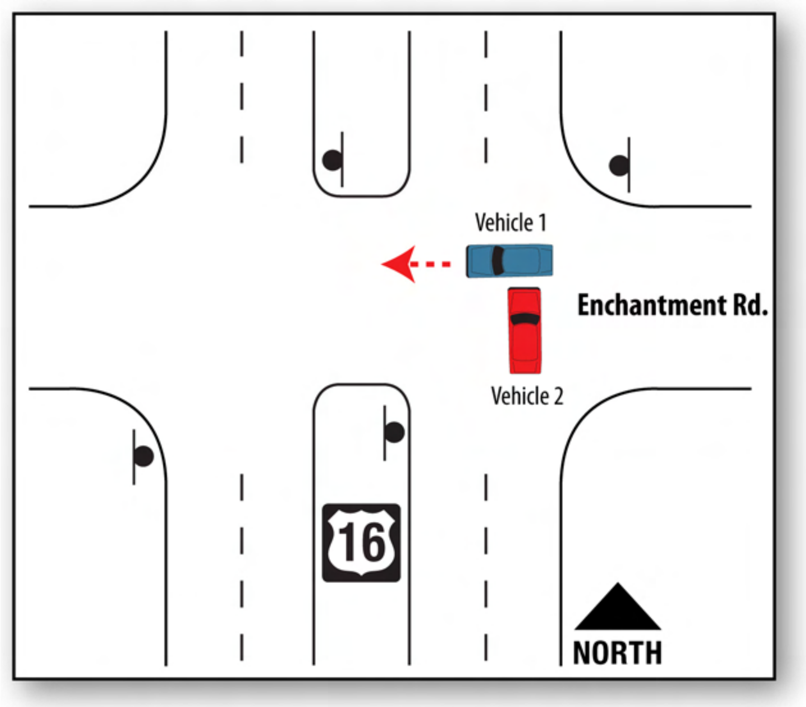
During the study period, there were 5 total crashes on this segment. There were 3 PDO crashes, 1 injury crash and 1 was the fatal crash. This segment is number 105 on the total crash critical crash ratio ranking list and is number 56 on the severe crash critical crash ratio ranking list.

Based on the isolated circumstances of this fatal crash and due to the low crash total on this segment, there does not appear to be a pattern in need of correction.

D. December 10, 2007 – US Highway 16 at Enchantment Road

This crash occurred when vehicle 1 in the westbound direction on Enchantment Road did not stop for the stop sign at Highway 16. Vehicle 2, northbound on Highway 16, collided with the driver side door of vehicle 1 (see **Figure 10**). The front seat passenger in vehicle 1 was not wearing a seat belt and received injuries resulting in a fatality. The driver of vehicle 1 received critical injuries. The driver of vehicle 1 was cited for a stop sign violation. This crash occurred in dark – lighted, frosty conditions.

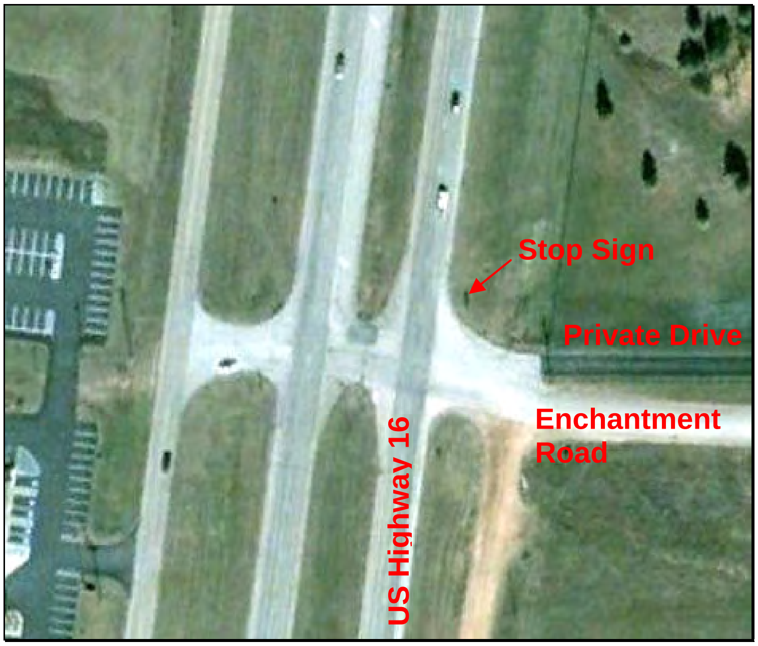
Figure 10. US Highway 16 at Enchantment Rd. Fatal Crash Diagram



During the study period there were 13 total crashes on this segment. There were 10 PDO crashes, 2 injury crashes and 1 was the fatal crash. This segment is number 140 on the total crash critical crash ratio list and number 63 on the severe crash critical crash ratio ranking list.

There is currently a stop sign located on the right side of the westbound approach to this intersection. However, this sign is well to the right of approach due to a driveway that intersects Enchantment Road from the northeast at an angle (see **Figure 11**).

Figure 11. Intersection of US Highway 16 and Enchantment Road

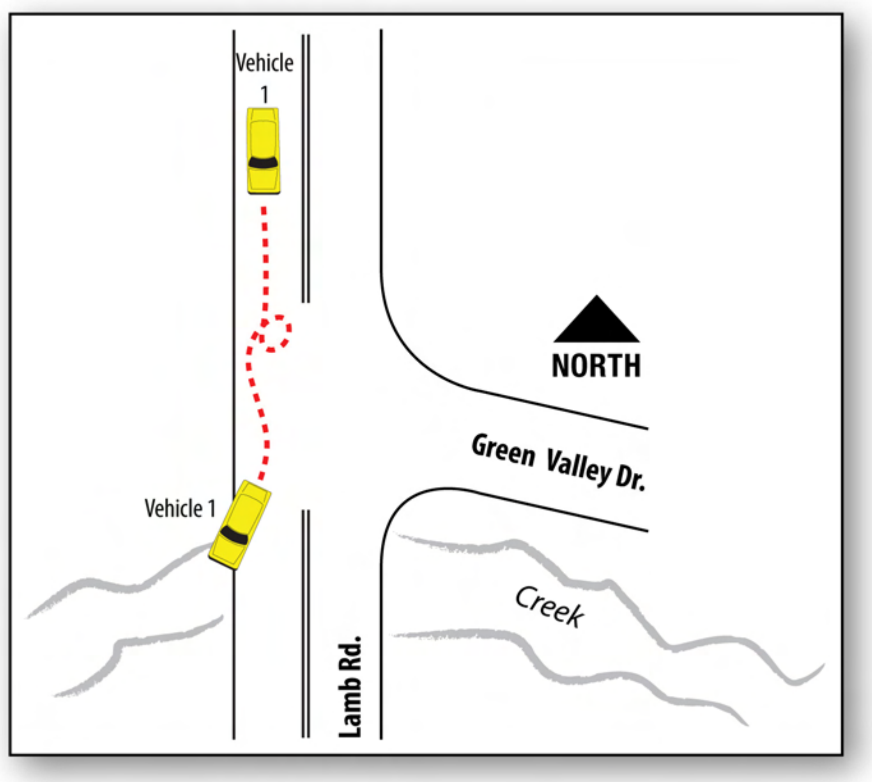


First, consideration should be given to relocating the intersection of the existing private drive further to the east so that it intersects with Enchantment Road in a more standard fashion. The width of the westbound approach can then be reduced which should help to improve the visibility of the existing stop sign. In addition, consideration should be given to installing oversized stop signs and an additional stop sign on the left side of the westbound approach of Enchantment Road. This should also help improve the visibility of the stop sign.

E. February 1, 2008 – Lamb Road near Green Valley Drive

This crash occurred when a vehicle in the southbound direction on Lamb Road drifted to the right and the passenger side tires left the road. The driver brought the vehicle back onto the road but overcorrected which sent the vehicle into a spin. The vehicle then struck a bridge guardrail which knocked the guardrail off of the bridge leaving the vehicle partially suspended over the edge of the bridge (see **Figure 12**). The driver of the vehicle was partially ejected and sustained fatal injuries. Alcohol was involved in this crash. This crash occurred in dark – unlighted, dry conditions.

Figure 12. Lamb Road Fatal Crash Diagram



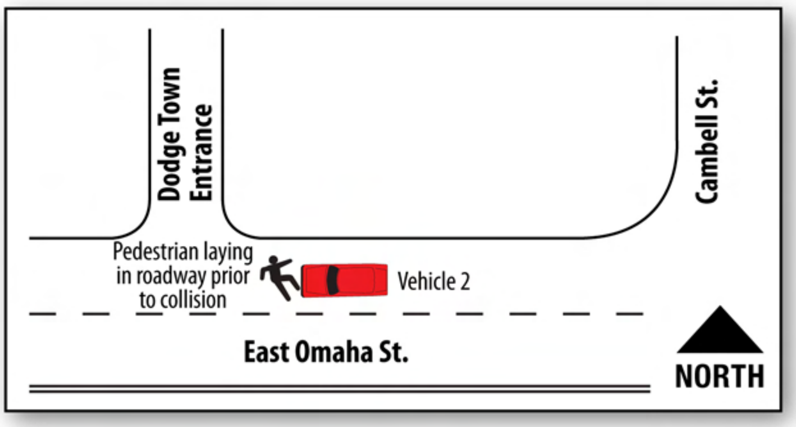
During the study period there were 7 total crashes on this segment. There were 6 PDO crashes and the one fatal crash. This segment is number 3 on the total crash critical crash ratio list and number 51 on the severe crash critical crash ratio ranking list. However, this segment was removed from further consideration as a top crash segment during Steering Committee discussions. This is due to the low daily traffic volume (approximately 200 vpd) during the study period.

Based on the isolated circumstances of this fatal crash, there does not appear to be a pattern in need of correction on this segment.

F. June 6, 2008 – East Omaha Street west of Cambell Street

This crash occurred when vehicle 2 turned right onto westbound East Omaha Street from Cambell Street and struck a pedestrian who was lying in the right lane of westbound Omaha Street (see **Figure 13**). The driver of vehicle 2 swerved to avoid the pedestrian but he was unable to react in time to avoid hitting the pedestrian. The pedestrian sustained severe injuries resulting in a fatality. This crash occurred in dry, dark – lighted conditions around midnight.

Figure 13. East Omaha Street Fatal Crash Diagram



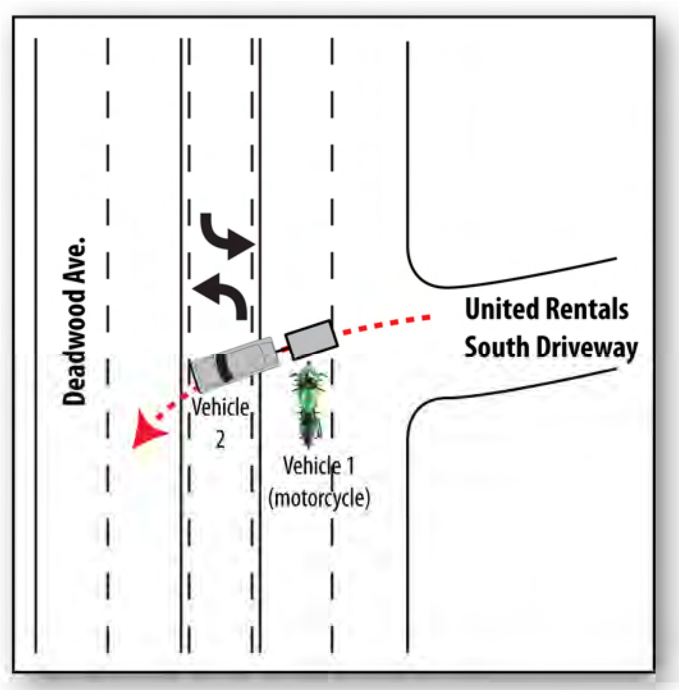
During the study period, there were 12 total crashes on this segment. There were 11 PDO crashes and 1 was the fatal crash. This segment is number 37 on the total crash critical crash ratio ranking list and is number 119 on the severe crash critical crash ratio ranking list.

Based on the isolated circumstances of this fatal crash and due to the low crash total on this segment, there does not appear to be a pattern in need of correction.

G. July 9, 2008 – Deadwood Avenue south of North Plaza Drive

This crash occurred when the trailer of vehicle 2 was struck by vehicle 1. Vehicle 2 was attempting to make a left hand turn from the United Rentals property onto southbound Deadwood Avenue. Vehicle 1 was a motorcycle headed northbound in the right lane of Deadwood Avenue (see **Figure 14**). The driver of vehicle 2 waited for a gap in traffic to make the left turn and proceeded. He judged the gap based on a maroon truck traveling in the left lane of northbound Deadwood Avenue that was traveling approximately 35 to 40 miles per hour. He began to make the left turn but then noticed vehicle 1 traveling in the right northbound lane at approximately 60 to 70 miles per hour (the posted speed limit is 45 mph). The driver of vehicle 2 accelerated in an attempt to complete the left turn and avoid a collision with vehicle 1 but was unable to get out of the way. Vehicle 1 struck the trailer and the driver of vehicle 1 sustained fatal injuries. This crash occurred in dry, daylight conditions.

Figure 14. Deadwood Avenue Fatal Crash Diagram



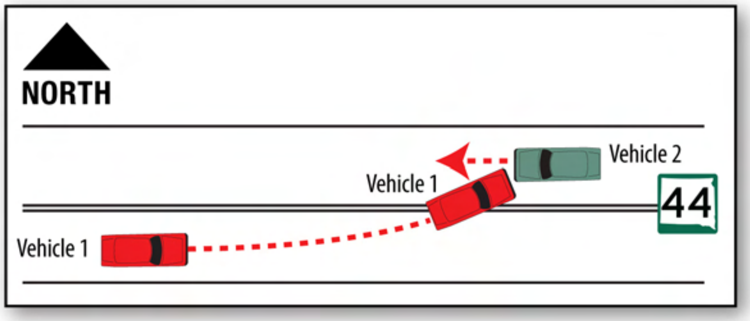
During the study period, there were 8 total crashes on this segment. There were 3 PDO crashes, 4 injury crashes and 1 was the fatal crash. This segment is number 169 on the total crash critical crash ratio ranking list and is number 53 on the severe crash critical crash ratio ranking list.

Based on the isolated circumstances of this fatal crash and due to the low crash total on this segment, there does not appear to be a pattern in need of correction. However, consideration should be given to increasing speed enforcement on this segment of Deadwood Avenue.

H. August 21, 2008 – South Dakota Highway 44 west of Falling Rock Road

This crash occurred when vehicle 1, driving eastbound on Highway 44, crossed into the westbound travel lane and collided with vehicle 2 head on (see **Figure 15**). The driver of vehicle 1 crossed into the westbound lane for an unknown reason. The driver of vehicle 2 attempted to avoid the collision but was unable to. The driver of vehicle 1 sustained fatal injuries. The driver and passenger in vehicle 2 sustained incapacitating injuries. This crash occurred in dry, daylight conditions.

Figure 15. Highway 44 west of Falling Road Road Fatal Crash Diagram



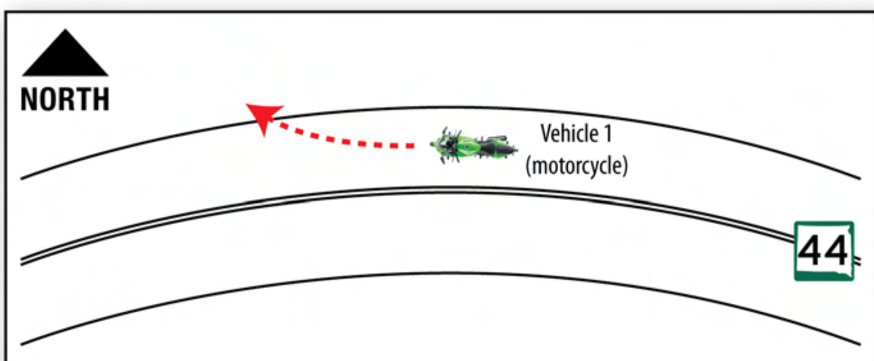
During the study period, there were 14 total crashes on this segment. There were 8 PDO crashes, 5 injury crashes and 1 was the fatal crash. This segment is number 68 on the total crash ranking list and number 15 on the severe crash ranking list.

Based on the isolated circumstances of this fatal crash, there does not appear to be a pattern in need of correction. However, consideration should be given to monitoring this segment given that it falls within the top 20 on the severe crash ranking list.

I. November 2, 2008 – South Dakota Highway 44 east of Elkhart Road

This crash occurred when the driver of vehicle 1, a motorcycle, stood up on the seat of the motorcycle and extended his hands out to his sides. The driver lost his balance and fell from the motorcycle onto the road surface. The motorcycle went off the road and hit a guardrail (see **Figure 16**). The driver sustained a fatal head injury from the fall. This crash occurred in dry, daylight conditions.

Figure 16. Highway 44 east of Elkhart Road Fatal Crash Diagram



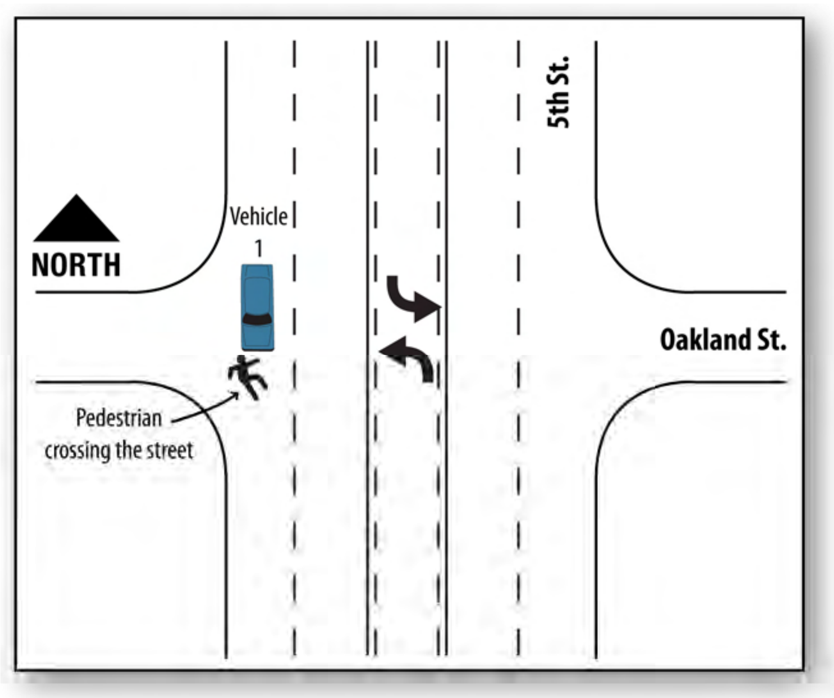
During the study period, there were 7 crashes on this segment. There were 6 PDO crashes and 1 was the fatal crash. This segment is number 81 on the total crash ranking list and number 116 on the severe crash ranking list.

Based on the isolated circumstances of this fatal crash and due to the low crash total on this segment, there does not appear to be a pattern in need of correction.

J. December 7, 2008 – 5th Street at Oakland Street

This crash occurred when a pedestrian crossing 5th Street on the south side of the intersection with Oakland Street was struck by a vehicle in the right southbound lane of 5th Street (see **Figure 17**). The driver of the vehicle stated he saw the silhouette of the pedestrian against the black sky when he was about 10 feet away from him. This crash occurred in dry, dark – lighted conditions and the pedestrian was wearing dark clothing at the time of the crash making it difficult for the driver to see him. The pedestrian sustained fatal injuries from the collision.

Figure 17. 5th Street at Oakland Street Fatal Crash Diagram



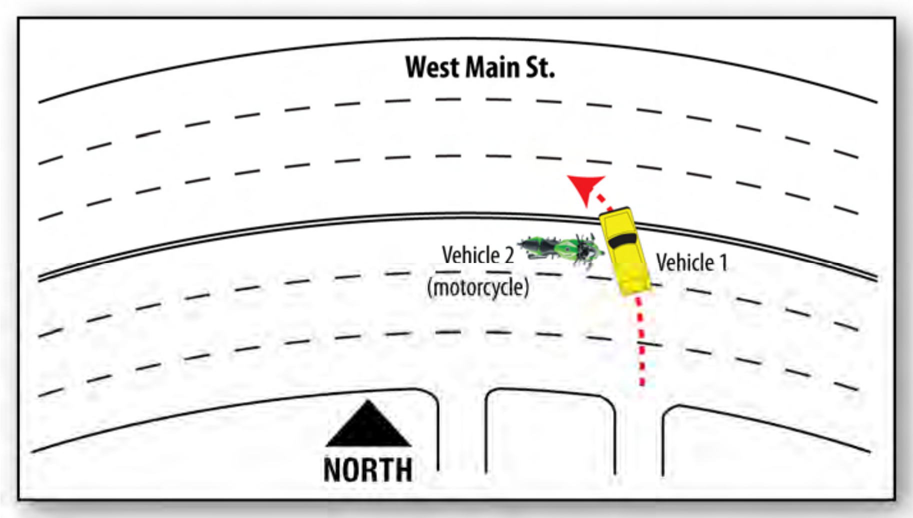
During the study period, there were 11 total crashes on this segment. There were 10 PDO crashes on this segment and 1 was the fatal crash. This segment is number 72 on the total crash ranking list and 130 on the severe crash ranking list.

Based on the isolated circumstances of this fatal crash and due to the low crash total on this segment, there does not appear to be a pattern in need of correction.

K. July 17, 2009 – West Main Street to the west of West Street

This crash occurred when vehicle 1, attempting to make a left turn onto westbound Main Street from a business driveway on the south side of West Main Street, turned out in front of vehicle 2, a motorcycle (see **Figure 18**). The driver of vehicle 1 said that he saw a gap in traffic and began to turn. The driver of vehicle 2 locked up the rear brake and laid the motorcycle on its right side in an attempt to avoid the collision. The driver of vehicle 1 accelerated in an attempt to get out of the way of vehicle 2. However, both the motorcycle and its occupants collided with the side of vehicle 1. Both the driver and the passenger of the motorcycle sustained fatal injuries. This crash occurred in dry, daylight conditions.

Figure 18. West Main Street Fatal Crash Diagram



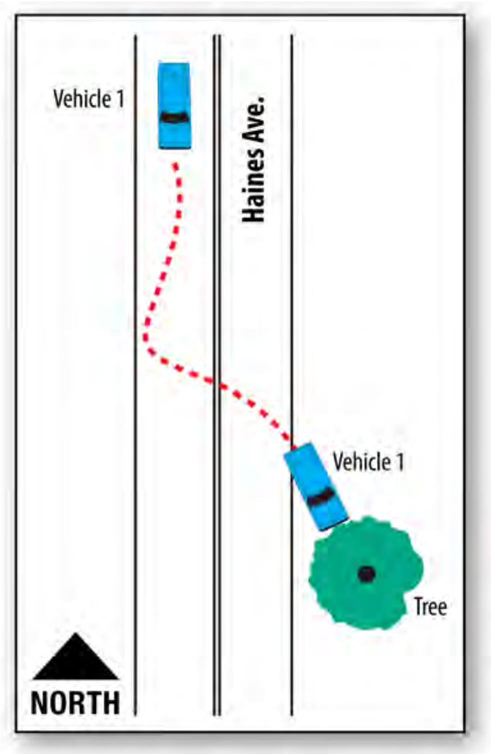
During the study period, there were 12 total crashes on this segment. There were 8 PDO crashes, 3 injury crashes and 1 was the fatal crash. This segment is number 117 on the total crash ranking list and number 64 on the severe crash ranking list.

Based on the isolated circumstances of this fatal crash and due to the low crash total on this segment, there does not appear to be a pattern in need of correction.

L. November 9, 2009 – Haines Avenue north of Country Road

This crash occurred when the driver of the vehicle drifted to the right and onto the shoulder while southbound on Haines Avenue. The driver over corrected, went off the left side of the road, rolled the car and came to rest against a tree (see **Figure 19**). This crash occurred sometime between midnight and 3:30AM but was not reported until about 3:45AM. The driver's blood alcohol content was above the legal limit and was estimated to be driving approximately 75 miles per hour. The posted speed limit is 50 miles per hour. The driver of the vehicle was ejected and sustained fatal injuries. The passenger of the vehicle sustained incapacitating injuries.

Figure 19. Haines Avenue Fatal Crash Diagram



During the study period, there were a total of 6 crashes on this segment. There were 5 PDO crashes and 1 was the fatal crash. This segment is number 114 on the total crash ranking list and number 124 on the severe crash ranking list.

Based on the isolated circumstances of this fatal crash and due to the low crash total on this segment, there does not appear to be a pattern in need of correction.

VI. COSTS AND PRIORITIZATION OF TOP CRASH SEGMENT CONCEPTS

For each of the concepts developed for the top crash segments, a conceptual level cost estimate was also developed. Tabulations for each of the opinions of probable cost can be found in **Appendix L**. Of note, in addition to materials, these estimates also include force account items such as utility relocations and engineering costs as well. **Table 4** shows the probable costs for each segment concept as well as the priority level given to each concept.

Table 4. Concept Costs and Prioritization

Segment Number	Road Segment Name	Recommended Concept	Opinion of Probable Cost	Critical Crash Ratio Total (Critical Crash Ratio Severe)	Priority Level	Priority Reasoning
Segment 1	Haines Ave. (Lindbergh to I-90)	Raised median, traffic signal warrant study and improved network grid	$1.6 million	2.43 (1.89)	High	Both critical crash ratios are high. There is a high potential for crash reduction.
Segment 2	Haines Ave. (I-90 to Disk)	Raised median and relocated access	$475,000	2.30 (1.88)	High	Both critical crash ratios are high. There is a high potential for crash reduction.
Segment 3	St. Joseph St. (5th to East Blvd)	Traffic signal warrant study, new striping and possible removal of parking	$400,000	2.02 (1.39)	High	Both critical crash ratios are high. There is a high potential for crash reduction.
Segment 4	Jackson Blvd. (City Limit to Chapel Ln.)	New signs and improving sight distance	$8,000	1.87 (0.00)	Low	One of two ratios is below 0.80. The potential for crash reduction is less likely.
Segment 5	W. Main St. (Sheridan Lake Rd. to Mountain View Rd.	Raised median, traffic signal warrant study, bike lane and widened cross section	$8.3 million	1.66 (1.36)	High	Both critical crash ratios are high. There is a high potential for crash reduction.
Segment 6	N. LaCrosse St. (Anamosa St. to Meridian Ln.)	Modified access (right-in / right-out)	$38,000	1.42 (0.74)	Low	One of two ratios is below 0.80. The potential for crash reduction is less likely.

Segment Number	Road Segment Name	Recommended Concept	Opinion of Probable Cost	Critical Crash Ratio Total (Critical Crash Ratio Severe)	Priority Level	Priority Reasoning
Segment 7	NB Highway 16 (Neck Yoke to Busted 5 Ct.)	Wildlife fencing, acceleration / deceleration lanes. Rumble strips and safety edge with resurfacing project	$1.4 million	0.90 (1.26)	Medium	One of two ratios is less than or nearing 1. The potential for some crash reduction is likely.
Segment 8	LaCrosse St. (E. North St. to Anamosa St.)	Traffic signal warrant study, crosswalks, RR crossing gates and modified access	$1.25 million	1.39 (0.99)	Medium	One of two ratios is less than or nearing 1. The potential for some crash reduction is likely.
Segment 9	W. Omaha St. (Mountain View Rd. to West Blvd.)	Update traffic signal warrant study if new development is constructed	$370,000	1.11 (1.08)	Medium	One of two ratios is less than or nearing 1. The potential for some crash reduction is likely.
Segment 10	E. St. Patrick St. (Elm Ave. to St. Joseph St.)	Review snow removal. Increase speed enforcement	-	0.77 (1.04)	Low	One of two ratios is below 0.80. The potential for crash reduction is less likely.

As can be seen in this table, there are four high priority concepts, three medium priority concepts and three lower priority concepts among the top crash segments. City staff should consider these priority ratings with regard to implementation of each of these concepts.

Once the crash problems on these top segments are addressed, the methodology presented in the report can be repeated and the next set of top arterial roadway segments can be addressed.

VII. CONCLUSIONS AND RECOMMENDATIONS

A. Summary of Project Goals and Objectives

Rapid City staff, in conjunction with the Rapid City Area Metropolitan Planning Organization (MPO), identified the need to complete an arterial roadway safety assessment within Rapid City. The goal of this safety assessment study was to maximize arterial segment crash reduction within the limitations of available budgets by making arterial roadway safety improvements at locations where it does the most good or prevents the most crashes. There are many considerations when it comes to improving roadway safety. These considerations are typically summarized as the 5 Es of roadway safety which include Evaluation, Engineering, Education, Enforcement and Emergency Services. This Arterial Street Safety Study focuses primarily on the Evaluation, Engineering and Enforcement Es. The City enlisted FHU and DDI to complete this assessment by determining the top ten crash segments and to conceptualize projects that will help to address the identified crash problems.

The analyses completed in this report utilize crash data from January 2007 through December 2009. The focus of this analysis and report is on the arterial roadway segments between major arterial to arterial intersections. City staff closely monitors the major intersections within Rapid City so this report does not include analyses for the major intersections within the City. As discussed in the introduction, the objectives of this study are as follows:

- Develop a citywide safety perspective to set localized crash frequency and severity in the context of other similar facilities in Rapid City.
- Identify the top ten arterial crash segments within Rapid City using the Critical Crash Rate Method as outlined in the Highway Safety Manual (AASHTO, 2010). This method utilizes past crash totals, daily traffic volumes and arterial segment lengths to calculate crash rates.
- Review each of the fatal crashes that occurred during the study period on arterial segments, to understand the circumstances surrounding each crash and determine if any measures can be taken to improve the safety of the arterial segments that each fatal crash occurred along
- Develop solutions with the greatest potential to improve arterial traffic safety for the top crash locations.
- Prioritize future safety improvements to make sure that limited improvement funding is spent in the right places.
- Provide the City of Rapid City with a repeatable methodology for analyzing arterial safety in the future using Geographic Information Systems (GIS) based methods.

B. Summary of Data and Methods

The data used in this analysis was provided by both City and SDDOT staff. The data utilized in this analysis was either provided in or imported to GIS. The data used in this analysis includes:

- Crash data (January 2007 to December 2009)

- Daily traffic volumes
- Arterial roadway laneage
- The 3-mile platting jurisdiction and 1.5 mile airport boundary used to define the study limits
- The City arterial roadway network
- The City intersection locations
- The City traffic signals locations

The arterial segments included in this study were then selected and segmented within ArcGIS. Section IIC of this report provides a step by step discussion of this process. Once defined, the Critical Crash Rate method as outlined in the Highway Safety Manual (AASHTO, 2010) was applied and the worst arterial crash segments within the study area were determined. The following is a portion of the table from Section IIIA of this report.

Table 5. Analyzed Crash Segments

Segment Number	Road Segment Name	From	To
Segment 1	Haines Ave	Lindbergh	I-90
Segment 2	Haines Ave	I-90	Disk
Segment 3	Saint Joseph St	5th	East Blvd
Segment 4	Jackson Blvd	City Limit	Chapel
Segment 5	W Main St	Sheridan Lake	Mountain View
Segment 6	N LaCrosse St	Anamosa	Meridian
Segment 7	S Highway 16 NB	Neck Yoke	Busted 5 Ct
Segment 8	N LaCrosse St	E North	Anamosa
Segment 9	W Omaha St	Mountain View	West Blvd
Segment 10	E Saint Patrick St	Elm	St Joseph

C. Summary of Recommendations for Top Segments and Fatal Crash Locations

A more in depth review of the crashes on each of the top segments was then completed in an attempt to identify correctable patterns. This was done by reviewing every crash report for the top crash segments. Both crash diagrams showing the locations of each crash on the top segments and conceptual designs were completed. **Appendix B** through **Appendix K** of this report contains both the segment crash diagrams and the conceptual designs for each of the top arterial segments.

In addition, each of the fatal crashes that occurred during the study period was also reviewed. This was done to obtain a better understanding of the circumstances surrounding each fatal crash and to determine if any measures can be taken to improve the safety of the arterial segment that each of these crashes occurred on. Upon review, there were a few segments identified for minor improvements.

Table 6 provides a brief summary of the recommended concepts for the top crash segments as well as the recommendations from the fatal crash analysis.

Table 6. Summary of Recommendations

Segment Number	Road Segment Name	Recommended Concept
Segment 1	Haines Ave. (Lindbergh to I-90)	Raised median, traffic signal (if warranted) and improved network grid
Segment 2	Haines Ave. (I-90 to Disk)	Raised median and relocated access
Segment 3	St. Joseph St. (5th to East Blvd)	Removal of parking, traffic signal (if warranted) and striping
Segment 4	Jackson Blvd. (City Limit to Chapel Ln.)	New signs and improving sight distance
Segment 5	W. Main St. (Sheridan Lake Rd. to Mountain View Rd.	Raised median, traffic signal (if warranted), bike lane and widened road
Segment 6	N. LaCrosse St. (Anamosa St. to Meridian Ln.)	Modified access (right-in / right-out)
Segment 7	NB Highway 16 (Neck Yoke to Busted 5 Ct.)	Wildlife fencing, acceleration / deceleration lanes. Rumble strips and safety edge with resurfacing project
Segment 8	LaCrosse St. (E. North St. to Anamosa St.)	Traffic signal (if warranted), RR crossing gates and modified access
Segment 9	W. Omaha St. (Mountain View Rd. to West Blvd.)	Traffic signal (if warranted)
Segment 10	E. St. Patrick St. (Elm Ave. to St. Joseph St.)	Review snow removal. Increase speed enforcement
Fatal Crash	US Highway 16 at Enchantment Road	Relocate existing private driveway, install oversized stop signs and additional stop sign on left side of Enchantment Rd. westbound approach
Fatal Crash	Deadwood Avenue south of North Plaza Drive	Consider additional speed enforcement
Fatal Crash	SD Highway 44 west of Falling Rock Road	Closely monitor due to top 20 severe crash ranking
Other Fatal Crash Locations	West Chicago Street just west of 40th Street	Based on the isolated circumstances and the low segment crash totals on these segments, there does not appear to be a pattern in need of correction
	5th Street just north of Fox Run Drive	
	SD Highway 44 at Cinnamon Ridge Road	
	Lamb Road near Green Valley Drive	
	East Omaha Street west of Cambell Street	
	SD Highway 44 east of Elkhart Road	
	5th Street at Oakland Street	
	West Main Street to the west of West Street	
	Haines Avenue north of Country Road	

D. Summary of Central Business District Findings

The crashes that occurred in the downtown area were reviewed separately from the other arterial crashes within the study. The primary reason for this is that the downtown area has unique geometric and travel conditions not typical of the other arterials in the study. The crashes in the downtown area were reviewed as a group in an effort to identify correctable patterns. Based on the review, rear end and angle crashes were the most common crash types in the downtown area with the majority of these crashes classified as property damage only crashes. This pattern is not uncommon due to the lower travel speeds and one way roadways common to a downtown area. No recommendations have been made to address crashes within the Rapid City central business district.

E. Summary of Costs and Priorities for Top Crash Segments

Opinions of cost were developed for each of the top crash segments and based on the potential for crash reduction; each segment was given a high, medium or low priority. **Table 7** provides a summary of the costs and priority levels associated with each segment. More information can be found in Section IV of this report.

Table 7. Segment Concept Costs and Priorities

Segment Number	Road Segment Name	Opinion of Probable Cost	Priority Level
Segment 1	Haines Ave. (Lindbergh to I-90)	$1.6 million	High
Segment 2	Haines Ave. (I-90 to Disk)	$475,000	High
Segment 3	St. Joseph St. (5th to East Blvd)	$400,000	High
Segment 4	Jackson Blvd. (City Limit to Chapel Ln.)	$8,000	Low
Segment 5	W. Main St. (Sheridan Lake Rd. to Mountain View Rd.	$8.3 million	High
Segment 6	N. LaCrosse St. (Anamosa St. to Meridian Ln.)	$38,000	Low
Segment 7	NB Highway 16 (Neck Yoke to Busted 5 Ct.)	$1.4 million	Medium
Segment 8	LaCrosse St. (E. North St. to Anamosa St.)	$1.25 million	Medium
Segment 9	W. Omaha St. (Mountain View Rd. to West Blvd.)	$370,000	Medium
Segment 10	E. St. Patrick St. (Elm Ave. to St. Joseph St.)	-	Low

F. Next Steps - Arterial Safety Study Project

It is recommended that City staff use the findings of this study to prioritize, plan, design and implement the safety projects deemed most effective in an effort to improve arterial roadway safety within Rapid City. In addition, the methods provided in this report provide City staff with the ability to reevaluate and reprioritize additional safety projects in the future as traffic volumes and crash occurrences change throughout the City. This reevaluation could be done at regular intervals as part of an ongoing arterial safety improvement program. The following provides the steps City staff may follow to reevaluate the arterial corridors within Rapid City utilizing the GIS analysis files developed for this report.

1. Obtain the most recent GIS shape (.shp) files for the crash data, arterial roadway network, intersections and platting boundaries. Most of these files are available from sources internal to the City but the most recent crash data can be obtained from the SDDOT.
2. Obtain the most recent daily traffic volumes and update the shape file created for this project that contains the arterial daily traffic volumes. This update of the daily volume shape file could be done on a regular basis by City staff even when not being utilized for safety analyses.
3. Join the most recent shape files listed above with the arterial buffers developed for this study and recalculate the crash rates for each segment, the citywide average crash rates for the arterial lane classification groups, the critical crash rates for each segment and the critical crash ratio for each segment. Complete this step for both the total number of crashes and the severe crashes (see page 11 of this report for the definition of a severe crash).
4. Rank the arterial segments first according to the total crash critical crash ratio and then by the severe crash critical crash ratio.
5. Develop two arterial segment top ten lists (one for total crashes and one for severe crashes).
6. Screen the top ten lists to verify that the segments included have not already been addressed or should be removed from the list for some other reason.
7. Develop a list of arterial segments for further evaluation.
8. For the top crash segments, review the crash types to identify patterns in need of correction.
9. Develop a list of recommended projects for each segment to address the identified crash pattern.
10. Develop cost estimates, prioritize projects and implement as funds become available.

These are the general steps to conduct a reevaluation but more detailed instructions on how to rerun the calculations as well as the GIS files to do so can be found on the compact disc (CD) provided to the City staff for this project. Please contact either Patsy Horton or Kip Harrington regarding the analysis file CD.